

METHOD AND APPARATUS FOR PROVIDING A WEB OF THERMOPLASTIC FILAMENTS

Field of the Invention

2 The present invention relates to a method and apparatus for providing a web of
thermoplastic filaments. In particular, the present invention relates to a method and
4 apparatus whereby a slot member is combined with an accelerator gun type tube system.

Background of the Invention

6 Through a typical spunbonding process, nonwoven fabrics are made by depositing
spun filaments on a moving support to form a web followed by bonding the web.

8 Generally, the thermoplastic filaments are first continuously extruded, quenched, drawn,
and attenuated by exposure to a high velocity fluid, and then deposited on the moving
10 support. The quality of the final web depends to a great degree on the relative
arrangement and uniformity of the filaments in the deposited web. The method and
12 apparatus used for drawing and attenuating the filaments will determine their uniformity
and arrangement in the web.

14 Manufacturers of non-wovens have made many innovations regarding such
drawing and attenuating methods and apparatuses. Generally, good separation between
16 filaments in combination with a high velocity for high rates of production is desired.
When separation between filaments is poor, strands undesirably become wrapped about
18 one another; a condition referred to as "ropiness". Ropiness in turn leads to poor
uniformity in the resultant web.

Early spunbonding processes typically utilized round tubes for drawing and
2 attenuating the filaments. High velocities of air were sent through the tubes to carry the
filaments through and direct them for depositing on a moving support below to form a
4 web. These tubes may be referred to as "Venturi tubes" or "attenuator guns", with the
"Lurgi" process one system of this type (use herein of any of these terms is generally
6 intended to be interchangeable). Systems such as these have several problems associated
with them. "Gun outs" can occur when one or more filaments break at the entry point of a
8 tube due to the aggressive handling created by the air acceleration in the tube. When a
gun out occurs, unattenuated fibers and polymer drips can fall directly onto the support
10 below. This can result in an expensive total line stoppage for cleaning of the support.

Additional problems are also associated with Lurgi tube systems. Inside the tubes
12 the filaments make contact with other filaments, which may result in them becoming stuck
together or entangled, causing a defect referred to as "ropiness". Additionally, the interior
14 of the tubes can become partially or completely blocked due to polymer deposits resulting
from drips or filaments contacting the tube inner surface. Finally, the high velocity of the
16 air in the tubes is associated with a general non-uniform or splotchy appearance to the
finished web, as the filaments are directed to the moving support with considerable force,
18 providing little opportunity for spreading or randomization. These various problems tend
to result in undesirable webs with low tensile strength.

20 Many attempts have been made to improve the performance of Lurgi tubes. For
example, U.S. Patent Nos. 3,163,753; 3,341,394; and 4,009,508 describe the use of
22 corona electrodes for charging the filaments electrostaticly in combination with use of a

Lurgi tube. Electrostatic charging tends to separate the filaments and thus to decrease ropiness and to otherwise result in a more uniform web. Although this method provides some improvement, it does not achieve fully satisfactory performance.

Alternate drawing and attenuation methods and apparatuses have also been developed. In particular, U.S. Patent Nos. 4,340,563 and 4,405,297 describe slot draw processes which replace Lurgi tubes with an elongated slot extending across substantially the whole web cross section to draw and attenuate filaments. Further advancements to the slot draw system are described in U.S. Patent Nos. 4,578,134; 5,397,413; 5,545,371.

These patents describe modifications to the slot draw process that include, respectively, a complex directed air stream, a corona treatment, and an air stream with water dispersed in it. The slot draw system in its various forms has generally resulted in improved filament drawing and attenuating for more uniform and efficient non-woven web production.

Lurgi tubes, however, remain in use for economic and performance related reasons. Because of the high velocity of air that is developed through the tube, tube attenuation offers superior filament crystallinity and orientation over slot draw systems, which have a lower air velocity and resultant lower crystallinity. Low crystallinity can result in low filament tenacity, and in filament shrinkage during subsequent thermal bonding. Also, because of the large capital investment required to install a slot draw system, it is not practical for many manufacturers having existing Lurgi tube systems to take advantage of the advances offered by a slot draw system.

There is therefore a need for improved Lurgi tube systems.

Prior efforts at improving such systems have included deflecting the filaments off
2 of a deflector plate mounted below the tube outlet. While this method broadened the
laydown pattern of the filaments in the web, good uniformity was not realized. Another
4 effort included mechanically oscillating one or more of the tubes, deflector plates, and/or
the web. These methods, however, were found to depend on the operating frequency of
6 the oscillating member(s), and also entailed numerous related maintenance problems.

Another proposed improvement to the Lurgi tube systems is described in U.S.
8 Patent No. 5,225,018 to *Zeldin* et al. *Zeldin* attaches a pair of tapered guide plates to a
row of Lurgi tubes to form a slot at the outlet of tubes prior to depositing filament on the
10 web. The plates are slanted at a precise angle so that turbulent air flow is developed in the
tapered slot formed between the plates. As the filaments exit the tubes and enter the
12 tapered slot, they are randomly spread by the turbulent air flow that exists in the slot.
Zeldin further includes corona means below the outlet of the tapered slot for additional
14 filament separation. *Zeldin's* device results in relatively randomly deposited filaments
across the width of the web, with a high ratio of cross direction filament depositing to
16 machine direction filament depositing.

The apparatus of *Zeldin*, however, leaves many problems with using Lurgi tubes
18 unresolved. Due to the high cross direction/machine direction ratio that webs have when
produced using the apparatus of *Zeldin*, for instance, Lurgi tubes are still unable to be
20 used for production of a relatively uniform web with a high machine direction orientation
and low machine direction elongation.

There is therefore an unresolved need in industry for an improved apparatus and
2 method for producing a uniform web of continuous filaments with high machine direction
strength, and high crystallinity.

4 Objects of the Invention:

It is an object of the invention to provide an apparatus and method for the
6 production of a uniform web of filaments having high crystallinity, and high machine
direction orientation.

8 Summary of the Invention:

The present invention generally comprises an apparatus and a method for
10 providing a uniform web of non-woven filaments having high crystallinity, high machine
direction orientation, and low machine direction elongation.

12 The apparatus of the present invention generally comprises filament transport
means having an exit, with a confined zone of reduced turbulence adjacent to the transport
14 means exit. As the filaments exit the transport means and are conveyed through the
confined zone where the conveying fluid velocity slows and turbulence is reduced, thus
16 spreading the filaments in a cross direction.

The transport means preferably comprise a plurality of Lurgi tubes, while the
18 preferred confined zone comprises a delivery slot defined by a slot member. The tube
exits are located adjacent to the elongated delivery slot. The preferred delivery slot is
20 defined by the substantially parallel first and second sideplates and substantially parallel

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endplates of the slot member. The sideplates and endplates are also parallel to the
2 transport means. Preferably, a tapered transition member is between the tube exit and
delivery slot entrance to aid in introduction of the filaments to the slot. The high velocity
4 fluid flow coming out of the tubes slows in the larger slot, allowing for spreading of the
filaments and discouraging ropiness. As the filaments travel through the tapered transition
6 member, they are spread in a cross direction along the elongated delivery slot. Because
the sidewalls are substantially parallel to one another and to the Lurgi tubes, the filaments
8 travel through the delivery slot without significant machine direction deflection, thereby
minimizing randomization (herein defined as machine direction deflection) and providing
10 high machine direction orientation.

The preferred apparatus of the invention further comprises electrostatic charging
12 means in one of the first or second side plates for electrostatically charging the filaments
with like charges as they travel through the delivery slot. The effect of having like surface
14 charges on the filaments is to have the filaments physically repel one another. The charged
filaments are thus further separated, thereby discouraging and even correcting filament
16 ropiness. Preferred electrostatic charging means comprise corona discharge pins in one of
the first or second sideplates extending along the length of the plate.

18 The preferred discharge pins are positioned inside the throat of the slot, so that the
filaments are spread while still in the slot. In this manner, the majority machine direction
20 orientation of the filament curtain is maintained, rather than encouraging a cross direction
randomization that would result should the filaments be charged after exiting the slot.

The apparatus of the invention may further preferably comprise means for
2 pneumatically carrying filament through the transport means and delivery slot, a moving
support member traveling below the delivery slot to receive the deposited web, and
4 bonding means for bonding the deposited web.

The method of the present invention comprises the sequential steps of transporting
6 filaments through transport means, which preferably comprise Lurgi tubes, and
transporting them through a confined zone of reduced turbulence. The filaments are
8 spread in a cross direction as they travel through the confined zone. The preferred
confined zone comprises a delivery slot defined by substantially parallel first and second
10 sidewalls, which are also substantially parallel to the Lurgi tubes. The filaments thus travel
through the preferred delivery slot with minimal randomization, while spreading uniformly
12 into a filament curtain in a cross direction. Preferably, the filaments are transported
through a tapered transition member between the transport means and the delivery slot for
14 further cross direction spreading of the filament curtain. Also, the filaments are preferably
electrostatically charged with like charges while traveling through the delivery slot so that
16 the individual filaments will repel one another and be further separated both within the slot
and while traveling between the slot and the moving support below.

18 The filaments are preferably transported pneumatically by air through the Lurgi
tube and delivery slot. Also, the method of the invention further comprises preferred steps
20 of depositing the web on a moving support below the slot, and subsequently bonding the
deposited web.

Using the method and apparatus of the invention, a significantly improved cross
2 direction spreading of filaments is achieved as compared to use of Lurgi tubes alone.

Because of the substantially parallel apparatus side and end plates, minimal filament
4 deflection in the machine direction occurs through the delivery slot. The method and
apparatus of the present invention thus result in a deposited web with high machine
6 direction orientation and low machine direction elongation, while having greatly improved
cross direction uniformity over use of Lurgi tubes alone. This is a result not possible using
8 a tapered slot. Further, the high fluid velocity possible in the tube transport of the present
invention results in improved filament crystallinity over conventional slot draw
10 attenuators. The method and apparatus of the present invention therefore resolves a
heretofor unresolved need in industry in a facile and efficient manner.

12 The above brief description sets forth rather broadly the more important features
of the present disclosure so that the detailed description that follows may be better
14 understood, and so that the present contributions to the art may be better appreciated.
There are, of course, additional features of the disclosure that will be described hereinafter
16 which will form the subject matter of the claims appended hereto. In this respect, before
explaining the embodiments of the disclosure in detail, it is to be understood that the
18 disclosure is not limited in its application to the details of the construction and the
arrangements set forth in the following description or illustrated in the drawings. The
20 present invention is capable of other embodiments and of being practiced and carried out
in various ways, as will be appreciated by those skilled in the art. Also, it is to be
22 understood that the phraseology and terminology employed herein are for description and
not limitation.

Brief Description of the Figures:

Fig. 1 is a perspective view of a preferred embodiment of the apparatus of the invention.

Fig. 2 is a cross section elevational view of the preferred embodiment of the apparatus of the invention.

Fig. 3 is a partial cross section elevational view of the electrostatic charging means of the preferred embodiment of an apparatus of the invention.

Fig. 4 is a partial cross section bottom view of the preferred embodiment of the invention.

Detailed Description:

Turning now to the drawings, Fig. 1 is a perspective view of a preferred apparatus of the invention, generally comprising slot member 2 attached to a plurality of transport tubes 4. The apparatus and method of the invention are suitable for use with transport means that include, but are not limited to, tubes that may be interchangeably referred to as Venturi tubes or gun attenuators. One of the more common systems utilizing such tubes is a Lurgi system. For purposes of illustration, reference within this disclosure is made to a Lurgi system with Lurgi tubes, but this should not be interpreted as a limitation on the apparatus or method of the present invention. It is also noted that Figure 1 illustrates the invention with eight Lurgi tubes; again, this is for illustration only, and not for limitation.

The apparatus and method of the invention may comprise a lesser or greater number of transport tubes.

Continuous filaments are fed to tubes 4 from an extruder beam 6 above. Molten thermoplastic polymer, which preferably comprises a polyolefin, polyamide, or a polyester, is fed to the extruder through line 8, and a plurality of individual filaments 10 are extruded through a plurality of orifices in extruder beam 6 into tubes 4. High pressure air is fed to tubes 4 by line 12. Air is directed downwards through tubes 4 to draw filaments 10. Preferably, air flows at a rate in the range of 6,000-9,000 m/min, as measured at the tube outlet. These air speeds have been found to convey the filaments at the preferred rate of between 2,000 to 3,000 m/min.

Fig. 1 also shows preferred support 14 moving below slot member 2, with a continuous filament web (shown in broken line) being deposited on moving support 14. The preferred distance between slot member 2 exit and support 14 is between 290-450 mm. The speed of support 14 may vary as may be desired to vary the bulk of the deposited web. Generally, the line speed of support 14 of the invention may be as is generally practiced in industry. Fig. 1 also shows heated calender rollers 16 for thermally bonding the deposited web.

Fig. 2 is a cross section of the preferred apparatus of the invention. Sideplates 20 and 22 are substantially parallel to one another, and to Lurgi tube 4. Sideplates 20 and 22 are preferably thick to resist bending, flexing, or other distortions, and so that substantially flat sideplates 22 and 24 may be easily fabricated. Delivery slot 26 is formed between sideplates 20 and 22. Transition member 28, which is comprised of tapered transition

plates 30 and 32, is between Lurgi tube 4 exit and delivery slot 26. Lurgi tube 4 and tapered plates 30 and 32 are preferably threaded for connection. Sideplates 20 and 22 may be joined at their top between Lurgi tubes to cover delivery slot 26 (not shown in Fig. 2); delivery slot 26 may also, however, be open at its top. Also, sideplates 20 and 22 may be held together by means as are generally known, including by screws. Endplates may cover respective ends of delivery slot 26, but are again not required. Should endplates be provided, they are preferably substantially parallel to one another and to Lurgi tube 4.

The preferred apparatus of Fig. 2 also comprises electrostatic charging member 34 installed in sideplate 22 such that it is substantially flush with sideplate interior surface 36.

Charging member 34 is connected to a voltage source 38, and sideplate 20 is connected to ground. To aid in good charge transfer, as well as to achieve the flow characteristics useful for the invention, the width of slot 26 is preferably narrower than the diameter of Lurgi tubes 4.

Fig. 3 is a partial cross sectional view of preferred charging member 34 flush with sideplate 22 surface 36. Charging member 34 preferably comprises a plurality of individual corona charging pins 40 arranged in an offset grid for improved charging and separation in a cross direction of filaments as they pass by member 34. Individual charging pins 40 are insulated from one another and from sideplate 22. Fig. 3 also shows endplate 42 attached to the end of sideplate 22 for covering an end of delivery slot 26 of Fig. 2.

Fig. 4 is a cross sectional view of the apparatus of the invention taken along the line 4-4 of Fig. 2. As discussed infra, sidewalls 20 and 22 are substantially parallel to one

another and to Lurgi tubes 4. Tapered transition plates 30 and 32 run the length of
2 delivery slot 26, and are between Lurgi tubes 4 and delivery slot 26. Electrostatic
charging member 34 is installed in sidewall 22 for charging filaments as they pass through
4 delivery slot 26. Fig. 4 also shows preferred endplates 42 and 44 attached to respective
ends of sideplates 20 and 22. Endplates 42 are substantially parallel to one another and to
6 Lurgi tubes 4.

As filaments flow out of Lurgi tubes 4 and into delivery slot 26, they are only
8 slightly deflected in a machine direction by tapered transition member 28, but are
substantially spread out in a cross direction along the length of delivery slot 26. This
10 provides for much improved uniform spreading of the filaments in a cross direction as
opposed to use of Lurgi tubes alone. The velocity of the fluid carrying the filaments
12 through Lurgi tubes 4 slows through slot 26, thereby discouraging ropiness and even
allowing for entangled filaments to disentangle. As the filaments pass charging member 34
14 they are charged with like charges, and thereby physically repel one another; further
separating themselves uniformly in a cross direction.

16 Because endplates 42 and 44 and sideplates 20 and 22 are all substantially parallel
to one another and to Lurgi tubes 4, the filaments pass from Lurgi tubes 4 and through
18 delivery slot 26 substantially without machine direction disturbance. This discourages the
kind of turbulence in delivery slot 26 that is developed in a tapered slot. Such turbulence
20 tends to result in a random web with low machine direction to cross direction ratio, and is
therefore undesirable for producing a web of high machine direction orientation. Also, the

charging member 34 of the present invention charges filaments as they pass within slot 26.

2 This is likewise advantageous for producing a web of high machine direction orientation.

It is also noted that the objects of the invention may likewise be achieved with
4 sidewalls 22 and 24 having an outwardly tapered orientation, although the parallel orientation is preferred.

6 A preferred method of the present invention comprises the sequential steps of transporting filaments through Lurgi tubes, through a tapered transition member, and into
8 a delivery slot. The delivery slot has substantially parallel first and second sidewalls, which are also substantially parallel to the Lurgi tubes. Preferably, the slot has a width (in
10 the machine direction) that is narrower than the individual tube diameters. Because of the slot orientation and parallel sidewalls, the filaments travel from the Lurgi tubes and
12 through the delivery slot with only minimal machine direction deflection, but with substantial cross direction spreading. Also, the filaments are electrostatically charged by a
14 plurality of corona charging pins while traveling through the delivery slot so that the individual filaments will repel one another and will be further separated in a cross
16 direction. The filaments are finally deposited on a moving support below the delivery slot to form a web. The preferred method of the invention further comprises depositing the
18 web on a moving support below the slot, and bonding the deposited web.

The apparatus and method of the present invention thereby take advantage of the
20 high fluid velocity of tube transport for its beneficial effects on crystallinity and throughput volume, while also taking advantage of the decreased filament ropiness and increased
22 cross direction uniformity provided by the delivery slot.

The advantages of the disclosed invention are thus attained in an economical,
2 practical, and facile manner. While preferred embodiments have been shown and
described, it is to be understood that various further modifications and additional
4 configurations will be apparent to those skilled in the art. It is intended that the specific
embodiments herein disclosed are illustrative of the preferred and best modes for
6 practicing the invention, and should not be interpreted as limitations on the scope of the
invention as defined by the appended claims.